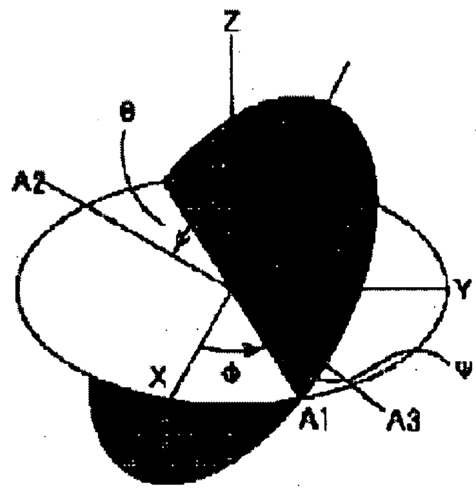
SURFACE ACOUSTIC WAVE ELEMENT

Publication number: JP8316781
Publication date: 1996-11-29
Inventor: SHIMIZU YASUTAKA; NISHIKATA ATSUHIRO; TOHA SHIGETAKA
Applicant: SHIMIZU YASUTAKA; SANYO ELECTRIC CO
Classification:
- international: ***H03H9/25;*** **H03H9/00;** (IPC1-7): H03H9/25
- European:
Application number: JP19950142672 19950517
Priority number(s): JP19950142672 19950517

Abstract of **JP8316781**

PURPOSE: To provide the surface acoustic wave element with high performance by finding out a cut face and a surface acoustic wave propagation direction more proper than those of a conventional element in a lithium niobate substrate and a lithium tantalate substrate. CONSTITUTION: When a cut face and a surface acoustic wave propagation direction of a piezoelectric substrate made of a lithium tantalate are selected to be (&phiv , &theta , &psi) in Euler angle representation and a range substantially equivalent thereto, the angle &phiv is 90 deg., &theta is 90 deg. and &psi is in a range of 0 to 180 deg.. Furthermore, when a cut face and a surface acoustic wave propagation direction of a piezoelectric substrate made of a lithium niobate are selected to be (&phiv , &theta , &psi) in Euler angle representation and a range substantially equivalent thereto, the angle &phiv is 90 deg., &theta is 90 deg. and &psi is in a range of 0 to 180 deg..



* NOTICES *

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the surface acoustic element which uses lithium niobate or lithium tantalate as piezoelectric material.
[0002]
[Description of the Prior Art] In communication equipment, such as portable telephone, the surface acoustic element is widely applied as circuit elements, such as a resonator filter and the delay line for signal processing. As shown in drawing 7 , a surface acoustic element forms a bamboo-blind-like electrode (2), a grid-like reflector (3), and (3) in the front face of the substrate (1) which has piezoelectric, and performs mutual conversion of an electrical signal and a surface acoustic wave. Generally, in the piezo-electric substrate of a surface acoustic element, it is required that an electromechanical coupling coefficient is large, that a propagation loss should be small, etc.
[0003] By the way, the needs for an usable surface acoustic element are increasing with the GIGAHERUTSU band with RF-izing of communication equipment in recent years. The center frequency f0 of a surface acoustic element is the velocity of propagation V of a surface acoustic wave, and relation with the electrode finger period L (= wavelength lambda), and is expressed by the degree type.
[Equation 1] $f0=V/L$ [0004] Therefore, in order to correspond to RF-ization of a surface acoustic element, the piezo-electric substrate with which the higher velocity of propagation (phase velocity) V is obtained needs to be developed. There are an approach using a hard substrate ingredient like a diamond and a method of using the so-called leakage surface acoustic wave in this. A leakage surface acoustic wave is an elastic wave which spreads a front face, emitting energy in the depth direction of an elastic body, and by choosing appropriately a cut side and the surface acoustic wave propagation direction, a propagation loss is made small and it can realize velocity of propagation still higher than the Rayleigh (Rayleigh) wave.
[0005] As a surface acoustic element using a leakage surface acoustic wave, the Xtal latest-starting-time cut, 41-degreeY-X cut of lithium niobate ($LiNbO3$), 64-degreeY-X cut, and 36-degreeY-X cut of lithium tantalate ($LiTaO3$) are known (137 Yasutaka Shimizu "present condition of propagation physical-properties [of a surface acoustic wave ingredient], and use" Institute of Electronics, Information and Communication Engineers paper magazine A Vol.J76- A, 2, pp129- 1993). Moreover, in the lithium tetraborate ($Li2B$ $4O7$) substrate, the leakage surface acoustic wave exceeding the phase velocity of a quick transverse wave is reported (Takahiro Sato, the 39th time study group data of Shusuke Abe "longitudinal-wave mold Leakey wave which spreads lithium tetraborate substrate" ****** 150 committee (6.6.23)). Since the phase velocity of this leakage surface acoustic wave is close to the phase velocity of a longitudinal wave, it is called the longitudinal-wave mold Leakey wave. Furthermore, the leakage surface acoustic wave which spreads the lithium-niobate substrate which has the cut side of arbitration is already reported (1318 pp1309- Yasutaka Shimizu, property [of a LiNbO3 substrate leakage surface acoustic wave], and Takashi Murakami "new cut" Vol.J69-C, 10, 1986).

[0006]
[Problem(s) to be Solved by the Invention] However, the phase velocity obtained with a conventional lithium tantalate substrate and a conventional lithium-niobate substrate is about 4000 m/s, and the cut side of a still higher phase velocity may exist. Moreover, it does not succeed in research there are few propagation losses and still sufficient about the optimal cut side and the surface acoustic wave propagation direction where an electromechanical coupling coefficient also with big ** is obtained. The purpose of this invention is offering the surface acoustic element of high performance for a suitable cut side and the surface acoustic wave propagation direction by the header and this rather than before in a lithium-niobate substrate and a lithium tantalate substrate.
[0007]
[Means for Solving the Problem] so, in this invention, the propagation property of the leakage surface acoustic wave in a lithium-niobate substrate and a lithium tantalate substrate was theoretically studied by boiling and changing various cut sides and the surface acoustic wave propagation directions. Consequently, the leakage surface acoustic wave of two types, i.e., the 1st leakage surface wave with the phase velocity between a late transverse wave and a quick transverse wave, (First Leaky Wave), and the 2nd leakage surface wave (Second Leaky Wave) with the phase velocity exceeding a quick transverse wave were resulted in completion of a header and this invention.
[0008] In addition, the general solution method conventionally known in the characterization of a surface acoustic element (for example) J. J.Campbell, W.R.Jones, and "A Method for Estimating Optimal Crystal Cuts and Propagation Directions for Excitation of Piezoelectric Surface Waves", IEEE transaction on Sonics and Ultrasonics, and vol.SU-15, No.4, pp 209-217, and reference (1968) were adopted, and phase velocity, the electromechanical coupling coefficient, and the propagation loss were computed by computer simulation. And about the optimal cut side and the surface acoustic wave propagation direction, when the surface acoustic element was actually made as an experiment and the property was surveyed, the measured value which coincides with a simulation result was obtained. The validity of computer simulation is supported by this.
[0009] The 1st surface acoustic element concerning this invention forms an electrode on the piezo-electric substrate which consists of lithium niobate, and when it is the Eulerian angle display of a right-hand system (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this, it is characterized by having set the range of 0 degree - 180 degrees, and theta as 90 degrees, and setting psi as 0 degree for phi.
[0010] More specifically, phi is substantially set as an equivalent include angle with 20 degrees, 40 degrees, 80 degrees, 100 degrees, 140 degrees, 160 degrees, or these include angles.
[0011] The 2nd surface acoustic element concerning this invention forms an electrode on the piezo-electric substrate which consists of lithium tantalate, and when it is an Eulerian angle display (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this, it is characterized by having set 90 degrees and theta as 90 degrees, and setting psi as the range of 0 degree - 180 degrees for phi.
[0012] More specifically, psi is substantially set as an equivalent include angle with 31 degrees, 164 degrees, or these include angles.
[0013] The 3rd surface acoustic element concerning this invention forms an electrode on the piezo-electric substrate which consists of lithium niobate, and when it is an Eulerian angle display (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this, it is characterized by having set 90 degrees and theta as 90 degrees, and setting psi as the range of 0 degree - 180 degrees for phi.
[0014] More specifically, psi is substantially set as an equivalent include angle with 37 degrees, 164 degrees, or these include angles.
[0015]
[Function] In the elastic surface element of the above 1st, in the cut (phi, 90 degrees, 0 degree) of a lithium-niobate substrate, all the range whose phi is 0 degree - 180 degrees is covered, and the high-

speed 1st leakage surface wave occurs rather than a Rayleigh wave. Moreover, as for the propagation loss of the 1st leakage surface wave in case a front face is electric disconnection, phi becomes abbreviation 0 20 degrees, 40 degrees, 80 degrees, 100 degrees, 140 degrees, and near 160 degree, and a value with a as high electromechanical coupling coefficient K2 as 16.2% is acquired.
[0016] In the 2nd surface acoustic element of the above, in the cut (90 degrees, 90 degrees, psi) of a lithium tantalate substrate, all the range whose psi is 0 degree - 180 degrees is covered, and the 2nd leakage surface wave which has one twice [about] the phase velocity of a Rayleigh wave occurs. Moreover, an electromechanical coupling coefficient K2 becomes [psi] 2.14% at 31 degrees, and when front faces are any of electric disconnection and an electric short circuit, as for the propagation loss of the 2nd leakage surface wave, psi becomes abbreviation 0 at 164 degrees.
[0017] In the 3rd surface acoustic element of the above, in the cut (90 degrees, 90 degrees, psi) of a lithium-niobate substrate, all the range whose psi is 0 degree - 180 degrees is covered, and the high-speed 2nd leakage surface wave occurs [phase velocity] extremely with about 7000 m/s. Moreover, an electromechanical coupling coefficient becomes [psi] 12.9% at 37 degrees, and, as for the propagation loss of the 2nd leakage surface wave, psi becomes abbreviation 0 at 164 degrees.
[0018]
[Effect of the Invention] While according to this invention a cut side and the surface acoustic wave propagation direction are appropriately set up in a lithium-niobate substrate and a lithium tantalate substrate and a phase velocity higher than before is obtained, there are few propagation losses and ** can also offer the surface acoustic element from which a big electromechanical coupling coefficient is obtained.
[0019]
[Example] Hereafter, along with the drawing per example of this invention, it explains in full detail. First, based on drawing 8 , the Eulerian angle (phi, theta, psi) for specifying a cut side and the surface acoustic wave propagation direction is explained. When setting a crystallographic axis to X, Y, and Z like illustration, only an include angle phi rotates the X-axis to a Y-axis side focusing on the Z-axis, and A1 shaft is set as this. Next, only an include angle theta rotates the Z-axis counterclockwise centering on A1 shaft, and this is made A biaxial. It cuts in the field bearing which includes A1 shaft by making this A biaxial into a normal, and considers as a substrate. And in the substrate cut into this field bearing, A3 shaft is set as the shaft which only the include angle psi made rotate A1 shaft counterclockwise focusing on A biaxial, and this A3 shaft is made into the surface acoustic wave propagation direction. At this time, a cut side and the surface acoustic wave propagation direction are displayed as an Eulerian angle (phi, theta, psi).
[0020] In the cut (phi, 90 degrees, 0 degree) of a lithium-niobate substrate, as for 1st leakage surface-wave drawing 1 and drawing 2 in a lithium-niobate substrate, a front face expresses the 1st leakage surface wave propagation property as a function of an include angle phi about both **** of electric disconnection (open) and an electric short circuit (short).
[0021] the case where the front faces of the phase velocity of the 1st leakage surface wave are any of disconnection and a short circuit as shown in drawing 1 -- the phase velocity of a Rayleigh wave -- a large -- it is that it is ****. Especially, when a front face is disconnection, it becomes a value near the rate of a quick transverse wave (Fast Shear Wave). However, the field where a solution is not acquired on the way exists in the include-angle range of phi ranging from 0 degree to 180 degrees. On the other hand, when a front face is a short circuit, the rate of the 1st leakage surface wave serves as a value near the rate of a late transverse wave (SlowShear Wave).
[0022] Thus, the difference of the rate in the case of being the case where a front face is disconnection, and a short circuit is large, consequently an electromechanical coupling coefficient becomes large. Drawing 2 expresses an electromechanical coupling coefficient K2 and the propagation loss per wave as a function of an include angle phi. Like illustration, the electromechanical coupling coefficient K2 serves as 25.1% of maximums near (phi= 0 degree, 60 degrees, 120 degrees, and 180 degrees).
[0023] On the other hand, a propagation loss serves as abbreviation 0 at phi= 20 degrees, 40 degrees, 80 degrees, 100 degrees, 140 degrees, and 160 degrees, when a front face is disconnection, and an

electromechanical coupling coefficient K2 serves as 16.2% and a big value by these cuts. However, a propagation loss is large when a front face is a short circuit.
[0024] In the cut (90 degrees, 90 degrees, psi) of a lithium tantalate substrate, as for 2nd leakage surface-wave drawing 3 and drawing 4 in a lithium tantalate substrate, a front face expresses the 2nd leakage surface wave propagation property as a function of an include angle psi about both **** of electric disconnection and an electric short circuit.
[0025] As shown in drawing 3 , the phase velocity of the 2nd leakage surface wave has one twice [about] the high phase velocity [about 6000 m/s and] of a Rayleigh wave, also when front faces are any of disconnection and a short circuit, and is very close to the phase velocity of a longitudinal wave (Longitudinal).
[0026] Drawing 4 expresses the electromechanical coupling coefficient and the propagation loss per wave. Like illustration, as for the electromechanical coupling coefficient K2, psi is 2.14% of maximums at 31 degrees. Moreover, a propagation loss in case a front face is electric disconnection is very smaller than the propagation loss in an electric short circuit. And as for the propagation loss, the front face serves as [psi] abbreviation 0 at 164 degrees in both **** of disconnection and a short circuit.
[0027] In the cut (90 degrees, 90 degrees, psi) of a lithium-niobate substrate, as for 2nd leakage surface-wave drawing 5 and drawing 6 in a lithium-niobate substrate, a front face expresses the 2nd leakage surface wave propagation property as a function of an include angle psi about both **** of electric disconnection and an electric short circuit.
[0028] As shown in drawing 5 , with about 7000 m/s, the phase velocity of the 2nd leakage surface wave is very high-speed, and is twice [about] the phase velocity of a Rayleigh wave. Moreover, the phase velocity of the 2nd leakage surface acoustic wave shows change which is different the case of electric disconnection, and in the case of an electric short circuit, and the difference among about 500 m/s has psi at 37 degrees, consequently a big machine electrical-and-electric-equipment coupling coefficient is obtained.
[0029] Drawing 6 expresses an electromechanical coupling coefficient K2 and the propagation loss per wave as a function of an include angle psi. Like illustration, psi is a value with a as big electromechanical coupling coefficient K2 as 12.9% of maximums at 37 degrees. Moreover, a propagation loss in case a front face is electric disconnection is very smaller than the propagation loss in an electric short circuit. And as for the propagation loss, the front face serves as [psi] abbreviation 0 at 164 degrees in both **** of disconnection and a short circuit.
[0030] In addition, although the property shown in drawing 1 thru/or drawing 6 is based on computer simulation, even if some errors in accordance with modeling of a surface acoustic element are in the above-mentioned characterization technique adopted by this example, it is thought that the error is hardly generated in drawing 1 thru/or the direction of an axis of abscissa of the graph of drawing 6 . When comparing the 1st leakage surface wave and the 2nd leakage surface wave concerning this invention with the conventional Rayleigh wave, since the error of the same magnitude as both is included, ** can also be referred to as uninfluential to an above-mentioned comparison result.
[0031] As a result of studying theoretically the 1st leakage surface wave and the 2nd leakage surface wave in a lithium-niobate substrate and a lithium tantalate substrate by this invention like ****, the surface acoustic element which can respond to a frequency band higher than before was completed for the optimal cut side and the surface acoustic wave propagation direction by the header and this about these substrates, respectively.
[0032] Explanation of the above-mentioned example is for explaining this invention, and it should not be understood so that invention of a publication may be limited to a claim or the range may be ****(ed). Moreover, as for each part configuration of this invention, it is needless to say for deformation various by technical within the limits given not only in the above-mentioned example but a claim to be possible.

[Translation done.]

CLAIMS

[Claim(s)]
[Claim 1] The surface acoustic element characterized by having set the range of 0 degree - 180 degrees, and theta as 90 degrees, and setting psi as 0 degree for phi when it is an Eulerian angle display (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this in the surface acoustic element in which the electrode for making a surface acoustic wave spread was formed on the piezo-electric substrate which consists of lithium niobate.
[Claim 2] phi is a surface acoustic element according to claim 1 set as 20 degrees, 40 degrees, 80 degrees, 100 degrees, 140 degrees, or 160 degrees.
[Claim 3] The surface acoustic element characterized by having set 90 degrees and theta as 90 degrees, and setting psi as the range of 0 degree - 180 degrees for phi when it is an Eulerian angle display (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this in the surface acoustic element in which the electrode for making a surface acoustic wave spread was formed on the piezo-electric substrate which consists of lithium tantalate.
[Claim 4] psi is a surface acoustic element according to claim 3 set as 31 degrees or 164 degrees.
[Claim 5] The surface acoustic element characterized by having set 90 degrees and theta as 90 degrees, and setting psi as the range of 0 degree - 180 degrees for phi when it is an Eulerian angle display (phi, theta, psi) and the cut side and the surface acoustic wave propagation direction of this piezo-electric substrate are substantially made into the equivalent range with this in the surface acoustic element in which the electrode for making a surface acoustic wave spread was formed on the piezo-electric substrate which consists of lithium niobate.
[Claim 6] psi is a surface acoustic element according to claim 5 set as 37 degrees or 164 degrees.

[Translation done.]

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] (phi, 90 degrees, 0 degree) It is a graph showing the property about the phase velocity of a surface acoustic element of having the lithium-niobate substrate of a cut.
[Drawing 2] It is a graph showing an electromechanical coupling coefficient same as the above and the property about a propagation loss.
[Drawing 3] (90 degrees, 90 degrees, psi) It is a graph showing the property about the phase velocity of a surface acoustic element of having the lithium tantalate substrate of a cut.
[Drawing 4] It is a graph showing an electromechanical coupling coefficient same as the above and the property about a propagation loss.
[Drawing 5] (90 degrees, 90 degrees, psi) It is a graph showing the property about the phase velocity of a surface acoustic element of having the lithium-niobate substrate of a cut.
[Drawing 6] It is a graph showing an electromechanical coupling coefficient same as the above and the property about a propagation loss.
[Drawing 7] It is the top view showing the example of 1 configuration of a surface acoustic element.
[Drawing 8] It is drawing explaining an Eulerian angle display.
[Description of Notations]
(1) Substrate
(2) Electrode
(3) Reflector

[Translation done.]

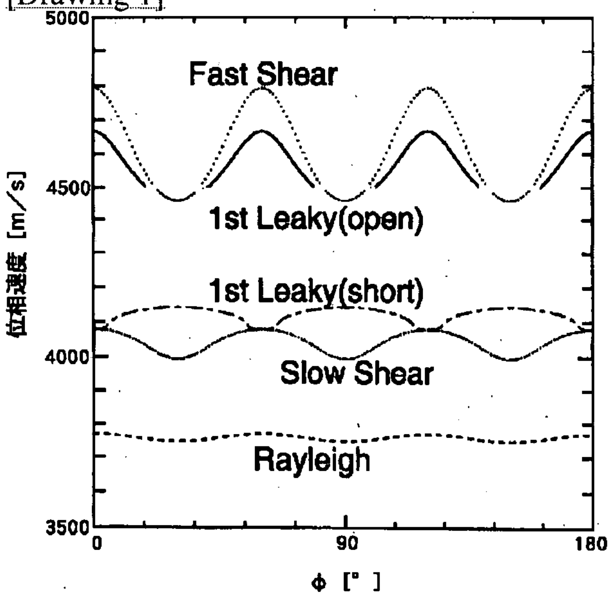
* NOTICES *

JPO and INPIT are not responsible for any damages caused by the use of this translation.

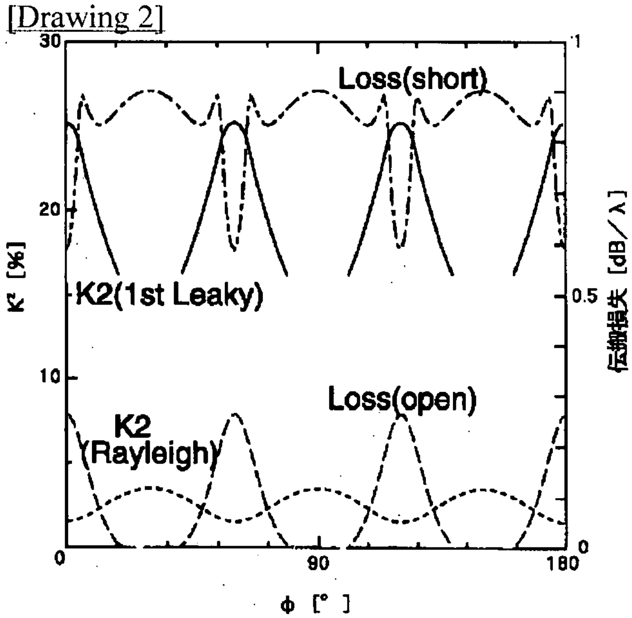
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

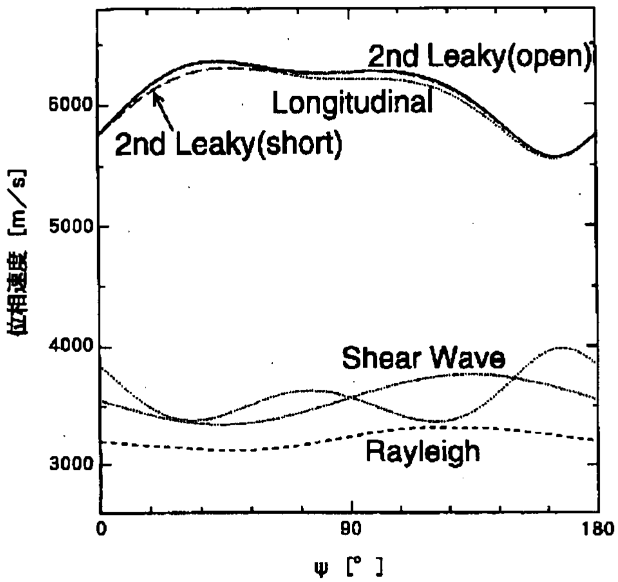
[Drawing 1]



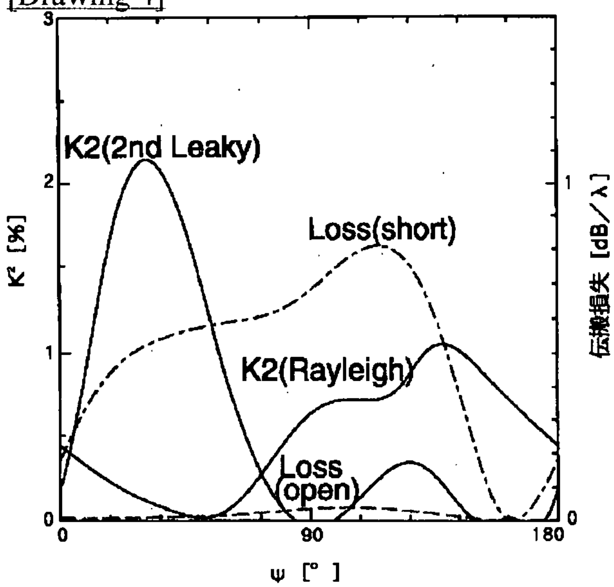
[Drawing 2]



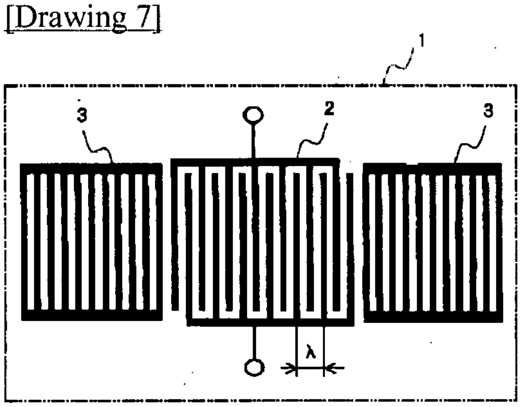
[Drawing 3]



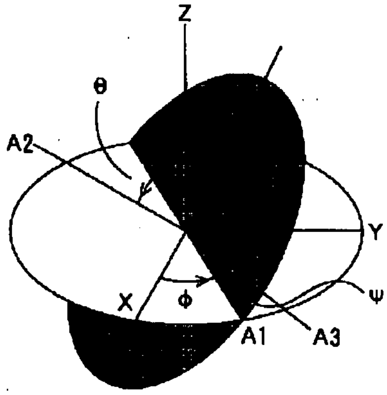
[Drawing 4]



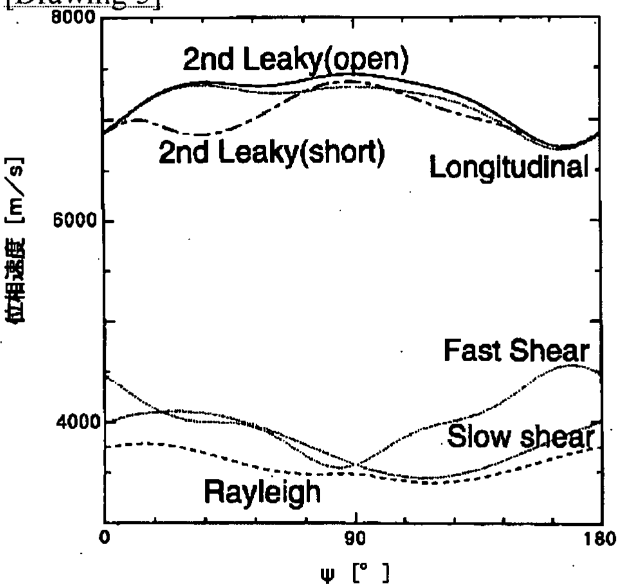
[Drawing 7]



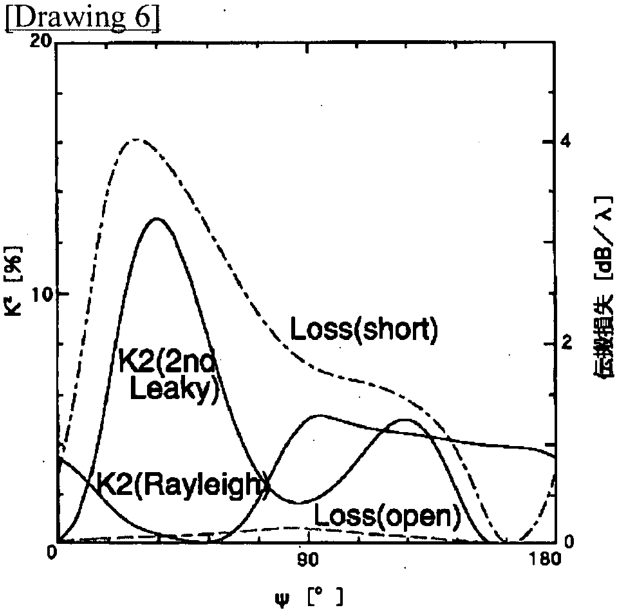
[Drawing 8]



[Drawing 5]



[Drawing 6]



[Translation done.]